Space Weather Technical Forecast

Issued on Thursday, 23 December 2021 at 01:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor Storm late on day 1 into day 2 (23rd/24th). Moderate X-ray flares possible throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been moderate over the past 24 hours, with numerous C-class flares observed, and one M1.3 flare at 22/0706UTC from AR2908 in the southwest quadrant. This may have produced a CME but further analysis is required if this will effect Earth. Further analysis is also required for a CME which left the Sun around 21/1930 UTC as this may have an Earth directed component.
There are presently 8 analysed sunspot regions on the visible disc, with three other plage regions in the eastern hemisphere exhibiting temporary spots over the past 24 hours. The most distinctive regions are a series of three sunspot regions in the southwest quadrant. 2907 has remained rather large and complex and is classified as Eai/Beta-Gamma. 2908 trailing spot penumbra has faded since producing the M-class flare and is now classified Cai/Beta-Gamma. 2909 has also seen decay in its trailing spots, simplifying to a Hax/Alpha region. There are also two more noteworthy sunspot regions near the east limb. 2916 has continued to rotate into view and is a large mature region, classed Eso/Beta. 2918 has shown rapid development over the past 12 hours and is now classified Cai/Beta. All other regions appear to be small simple unipolar or bipolar regions, with significant flare activity unlikely, but will continue to be monitored for development.

Solar Wind / Geomagnetic Activity: Solar winds speeds as measured by DSCOVR at L1 have been elevated and steady throughout, between 560 and 590 km/s. Density has also been stable through the period, but slightly above average, ranging between 12 and 16 ppcc. Interplanetary magnetic field strength (IMF), Bt has been weak throughout, with the north-south component, Bz also varying weakly. Phi angle has been predominantly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at background levels. The high energy electron flux (greater than 2 MeV) was at mainly background levels, but did temporarily peak into the High, reaching 1190 pfu at 22/1715 UTC. The associated 24-hour integrated fluence remained below the Active (1e8 integrated pfu) threshold but with a gradual rising trend, reaching 5e7 by 23/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate solar activity is expected to continue through the forecast period, with C-class flares expected, a chance (40%) of further M-class flares and a slight chance (5%) of an X-class. There are also a number of filaments in the southern hemisphere which, while currently stable, continue to be monitored. A CME which left the Sun on 20th December from AR2908 is forecast to arrive at Earth on late on the 23rd December.

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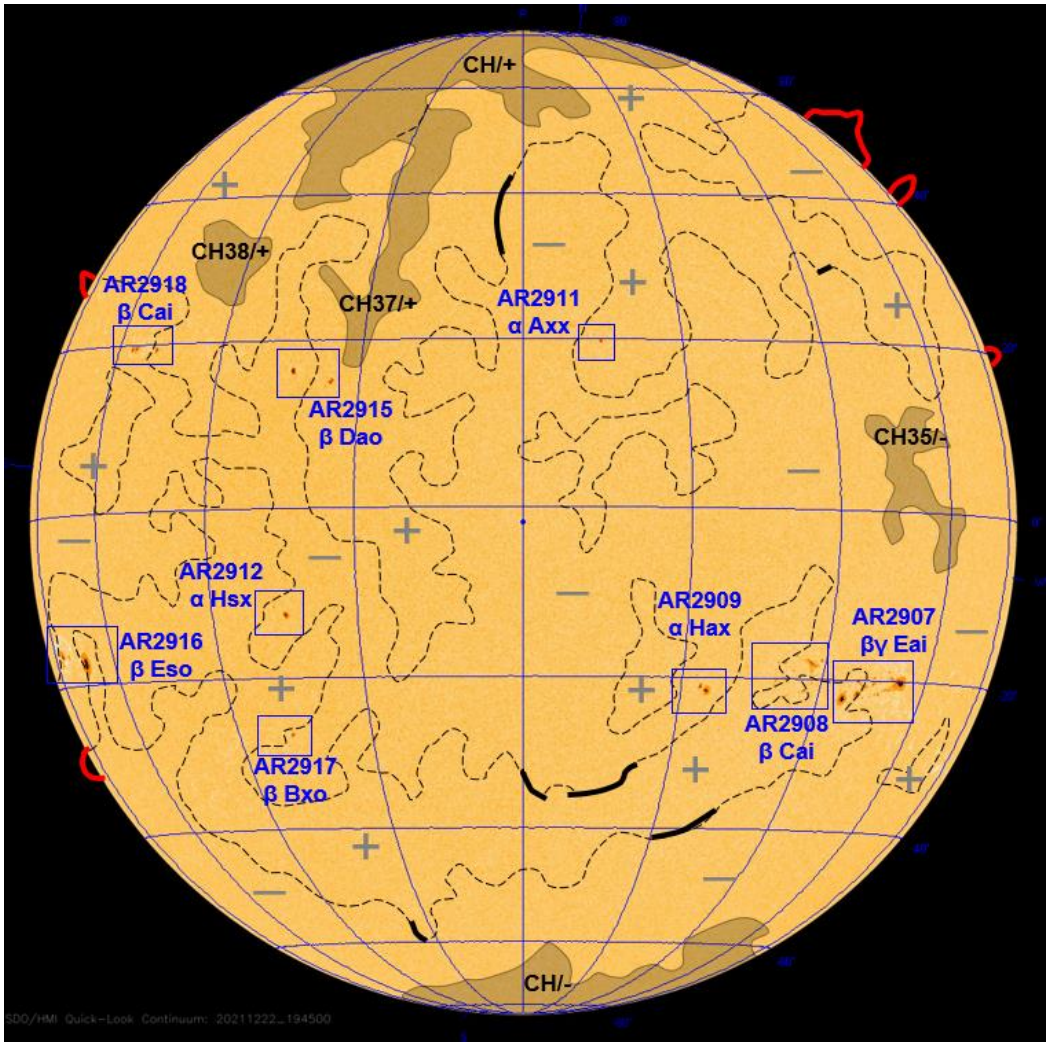
Solar Wind / Geomagnetic Activity: Elevated solar winds should begin to decline as the effects of CH35 wane. However, further enhancement of the solar wind is likely to take place late on the 23rd into the 24th due to the CME mentioned above. On day 3 (25th) solar winds should return to ambient levels, but towards the end of the forecast period they may become elevated once again due to CH37. Quiet to Unsettled geomagnetic activity is generally expected through days 1 and 2 (23rd and 24th), with Active intervals likely in association with the CME, when there is a chance of a G1/Minor Storm. Predominantly Quiet geomagnetic activity is expected on days 3 and 4 (25th and 26th), but perhaps becoming Unsettled to Active later on day 4 (26th).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels and below the S1 level, although there is a very slight chance for some increased flux from any significant flare activity. High energy electron flux has been at mainly moderate levels and may exceed the high threshold on day 1 (23rd), but any increase in flux is likely to be by the forecast CME arrival. Electron fluence is likely to initially follow an increasing trend, but is likely to remain below the Active (1e8 integrated pfu) threshold throughout the period.

Figure 1. Solar Analysis Valid 22/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Earth is currently being influenced by the high speed stream from coronal hole 35 (CH35), which is producing elevated wind speeds around 570 km/s. Solar winds should gradually decline through days 1 and 2 (23rd and 24th) as CH35 rotates from a geoeffective position and its effects wane. However, further enhancement is likely from a CME which left the Sun on 20th December. This is forecast to arrive at Earth later on day 1 (23rd) into day 2 (24th). On day 3 (25th), solar winds are likely to return to ambient levels, but towards the end of the forecast period they may become elevated once again as CH37 approaches a geoeffective position.
Quiet to Unsettled geomagnetic activity is generally expected through days 1 and 2 (23rd and 24th), with Active intervals likely in association with the CME, when there is a chance of a G1/Minor Storm. Geomagnetic activity is likely to become predominantly Quiet on days 3 and 4 (25th and 26th), however the is a chance of Unsettled/Active activity later on day 4 (26th) if connection is made with CH37.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	20	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/1804 UTC	Partial	AR2908	S14 E11	625 km/s	23/1200 UTC	Limited shock

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Radio Blackouts - X-Ray Flares:

There are presently 8 analysed sunspot regions on the visible disc, with three other plage regions in the eastern hemisphere exhibiting temporary spots over the past 24 hours. A M1.3 flare was observed from AR2908 at 22/0706 UTC and 3 other notable C-class flares were observed over the past 24 hours, meaning solar activity was Moderate.
Low to Moderate solar activity is expected to continue through the forecast period, with C-class flares expected, a chance (40%) of further M-class flares and a slight chance (5%) of an X-class. These are most likely to come from 2 sunspot regions in the southwest quadrant; AR2907 Eai/Beta-gamma and AR2908 Cai/Beta-gamma, or from 2 regions near the east limb; AR2916 Eso/Beta and AR2918 Cai/Beta.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at background levels.
Despite the large number of sunspots on the disc, a number of which are now moving into an improved geoeffective location for radiation storms, their small size and generally simple magnetic structure means that proton rich flaring is unlikely.
Background levels are expected to persist, with a chance of some small increases from any notable flares that do occur. However, there is only a very slightly above background risk of rising to the S1 alert level.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) at GEO has been close to the high (1e3pfu) threshold and is expected to continue at this level, with a chance of exceeding the threshold on day 1 (23rd) during the diurnal maximum, due to a consistently elevated high speed stream. However, increased geomagnetic activity in association with a CME late on day 1 into day 2 (23rd/24th), is likely to lead to a redistribution of electrons within the radiation belts.
Electron fluence values are showing a slight levelling off after a previous steady but sustained increase. The anticipated CME effects are likely to hinder any significant increase from day 2 (24th) onwards, with only a slight chance of exceeding the Active (1e8 integrated pfu) threshold through the period.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\,sr^{-1}\,day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	20	20	5	10
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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